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Abstract Title: Pre-Launch Performance Characteristics of the Atmospheric Infrared Sounder (AIRS).

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Abstract:

Background:

The Atmospheric Infrared Sounder represents a quantum leap in spaceborne sounding instruments with 2,378 infrared spectral channels ranging in wavelength from 3.5 to 15.5 microns. AIRS was built by NASA subcontractor Lockheed Martin Sanders (LM Sanders) in Lexington Massachusetts and is scheduled for launch on the NASA EOS-Aqua spacecraft in December 2000. AIRS is currently undergoing integration with the Aqua spacecraft at TRW in Redondo Beach, California. With a spectral resolution of

better than 1200 and a radiometric sensitivity of better than 0.2K, and spatial resolution of 1.1 degrees, AIRS is expected to greatly enhance atmospheric temperature and water vapor retrievals when compared to its predecessors.

Characterization of this high spectral resolution infrared spectrometer involved extensive laboratory testing in a thermal vacuum environment at cold optical temperatures. This paper summarizes the results of that testing and gives a detailed report on the spectral, radiometric and spatial performance of the AIRS. Radiometric, spectral and spatial accuracy predictions are presented. Infrared polarization measurements were made on the spectrometer and their impact to the instrument radiometry is discussed.

Materials and Methods

The AIRS requires low backgrounds at the focal plane assemblies to achieve the necessary radiometric sensitivities. The high spectral resolution results in very low signal levels that must be differentiated from background noise. For this reason, the AIRS spectrometer must operate at cold temperatures, i.e. approximately 155K. AIRS incorporates passive radiative cooling for the optical assembly, and active cryogenic cooling for the infrared detectors. The AIRS was placed in a thermal vacuum chamber and configured to allow the radiator plates to view a cold target. Testing was performed with the spectrometer at 149K, 155K and 161K to bound the expected range of operation in the orbital environment. Performance measurements at these three temperatures are presented. The AIRS Focal Planes were maintained at approximately 60K throughout the test program using the on-board pulse tube split sterling cycle coolers.

The infrared radiometry was characterized with a Large Area Blackbody (LABB). The LABB was manufactured by BOMEM of Quebec City, Canada and is traceable to NIST standards through the temperature sensors. The LABB is a cavity design with a 27.25 degree wedge angle. Infrared spectral response was characterized with a Bruker Instruments Model IFS-66V Fourier Transform Infrared (FTIR) Spectrometer. The FTIR has a maximum spectral resolution of 0.1cm^-1 with two sided interferograms with 5cm maximum optical retardation. Spatial characterization was performed with a Spatial Collimator System (SCS) that allows two axis scanning of a 0.1 degree field of view. Polarization is characterized using the SCS with linear wiregrid polarizers at the source. Photos and diagrams of the test equipment are presented.

Results:

Radiometric measurements on the AIRS show the overall spectrometer is performing as expected. We see near background limited performance for the majority of the shorter wavelength channels. Radiometric accuracy and stability are very good due to the cold temperature controlled optics. In-Flight calibration is achieved through transfer to the on-board blackbody assembly. Radiometric sensitivity and accuracy are presented in the paper.

Polarization measurements show the AIRS has the anticipated high degree of polarization which is not believed to be a problem due to the unpolarized nature of the atmosphere. However, this polarization does cause a modulation with the scan mirror orientation (scan mirror angle is fixed in airs) that has been characterized. Results of the characterization compare favorably with modeled expectations and are presented in the paper (references 1 and 2).

Spectral testing has shown the AIRS to response functions which are very well behaved with minimal out of band response. A small amount of "channeling" is seen in the response functions due to entrance filters placed perpendicular to the input beam that is well characterized. Spectral resolution and representative response profiles are presented.

Spatial response profiles show a very sharp 1.1 degree circular beam. The spatial response of all channels coincides to better than 97%. Top hat profiles are available for all 2378 channels of AIRS and representative ones are presented in the paper.

Discussion

AIRS has exceptional performance and stability with temperature. AIRS meets or exceeds the majority of requirements and all noncompliances have been approved by the science team. All necessary characterization data has been obtained and allow us to transfer the calibration of the AIRS to the in-orbit configuration. We expect AIRS to meet all expectations providing an exceptional level of sensitivity, accuracy and stability for atmospheric sounding measurements.

References

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2. "AIRS instrument polarization response: measurement methodology", (co-author), SPIE 3759-30, July 1999
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Biography:

Thomas S. Pagano is a Sr. Systems Engineer at JPL working primarily on the Atmospheric Infrared Sounder program as Systems Analysts. Prior to working at JPL, he was Chief Systems Engineer for the MODIS instrument at Raytheon Santa Barbara Remote Sensing for the EOS-Terra platform and saw that instrument from concept development in 1985 to delivery to the spacecraft in 1997. He has a BS in Physics from UC Santa Barbara, and an MS in Physics from Montana State University. He holds 2 US patents and is author of numerous papers on space remote sensing systems.